

METAL CONDENSATES IN CH AND BENCUBBIN-LIKE CHONDRITES: EVIDENCE FOR LOCALIZED NEBULA HEATING EVENTS AND VARIATIONS IN GAS COMPOSITION. A. Meibom HIGP/SOEST, University of Hawai'i at Manoa, Honolulu, HI 96822, USA, (meibom@pgd.hawaii.edu), A.N. Krot, M.I. Petaev, L. Wilson, R. Reisener, J.I. Goldstein, M. Norman, A.J. Campbell, V. Bennett, J. Nuth, P. Wasilewski, P. Bland, R.M. Hough, P. Trimby, and K. Keil.

Introduction: It was shown recently that compositionally zoned metal grains (\varnothing : 10-400 μm) (wt% throughout) (5-10% Ni, 0.25-0.4% Co, 0.3-0.8% Cr, ~0.07% Si) in CH and Bencubbin-like chondrites [1, 2] formed by condensation from a gas of solar composition, and subsequently escaped chondrule formation and thermal metamorphism [3]. Here we report further observations of metal grains in CH chondrites (PAT91546, PCA91467, RKP92435, ALH85085, EET96238, and Acfer 182) and in the Bencubbin-like chondrite QUE94411 [2]. We find compositionally zoned FeNi metal grains with a wide range of Ni concentrations (~5-60% Ni). We suggest that metal in CH and Bencubbin-like chondrites can be used to constrain the total pressure (P_{tot}), oxygen fugacity, and cooling rates of the nebula regions, where these metal grains condensed, and the rate of grain growth. We infer that these metal grains formed by gas-solid condensation from a gas with variable $f\text{O}_2$ in rapid and localized thermal episodes in the solar nebula.

Results: Metal grains in CH and Bencubbin-like (QUE 94411) chondrites can be divided into three categories: **1.** Concentrically zoned metal grains (*type 1*) with Ni concentrations decreasing from the center (9-14%) to the edge (3-7%) [1]. Cobalt (0.2-0.5%) is positively correlated with Ni with a solar Co/Ni ratio (~0.045), whereas Cr (0.2-0.8%) is negatively correlated with Ni. Phosphorous and Si concentrations are 0.1-0.3% and 0.05-0.15%, respectively. **2.** Compositionally homogeneous low-Ni (5-7% Ni) metal grains (*type 2*), with a ~solar Ni/Fe ratio (~0.055), 0.6-0.8% Cr, a solar Co/Ni ratio (0.2-0.3% Co), and 0.3-0.4% P; Si <0.02%. **3.** High-Ni metal grains with Ni concentrations ranging from 25% to 60% (*type 3*) and ~solar Co/Ni ratios. Chromium and P concentrations are near the detection limit (~0.05%); Si <0.02%. Some of the high-Ni (~53-58% Ni) grains are concentrically zoned in a way similar to type 1 grains.

Discussion: Meibom *et al.* [1] showed that *type 1* metal grains are the result of equilibrium condensation from a gas of solar composition at 1400 to 1300 K at $P_{\text{tot}}=10^{-4}$ bars [3]. Assuming spherical geometry of the growing grains and grain growth by bombardment of Fe and Ni atoms (sticking coefficient = 0.5) from a gas of solar composition, $P_{\text{tot}} 10^{-4}$ bars, and temperatures around 1400 K, we calculate that it takes a few days to grow metal grains several hundred microme-

ters in diameter. This puts a lower limit on the cooling rate of the gas at ~10 K/day, fast enough to avoid homogenization of the compositionally zoned metal grains by solid-state diffusion. This provides compelling evidence for brief thermal episodes in localized solar nebula regions.

The composition of *type 2* (low-Ni, homogeneous) metal grains is generally consistent with equilibrium condensation from a gas of solar composition at temperatures below 1250 K [3], when the Ni/Fe ratio of the condensing metal is ~solar (~0.055).

High-Ni metal grains (*type 3*), some of which are compositionally zoned similarly to grains of type 1, might also have formed by gas-solid condensation. However, because the first metal to condense from a gas of solar composition and total pressure between 10^{-3} - 10^{-5} bars is expected to have <28% Ni, condensation of metal with higher Ni concentrations requires more oxidizing conditions. This could be achieved by evaporation and subsequent cooling of a gas-parcel with an initial dust/gas ratio 10-100 x solar, or by removal of H_2 . We infer that the high-Ni metal grains in CHs provide evidence for variable redox conditions in the regions of metal condensation.

In order to further explore the origin of metal in CH and Bencubbin-like chondrites, we are undertaking a multi-faceted study that includes: **a.** Detailed thermodynamic and physical modeling of metal condensation under various redox conditions. **b.** ICP-MS and X-ray microprobe analyses of moderately volatile elements (Ga, Ge, As, Au etc.) and PGEs in type 1 metal grains to constrain the behavior of these elements during condensation. **c.** High-magnification SEM and Mössbauer spectroscopy to determine the degree of metal decomposition and constrain the growth mechanism and subsequent thermal history of the metal grains. **d.** Ion-probe measurements of Ni and Cr isotope compositions to search for anomalies that might be related to early nebula mixing/evaporation processes. **e.** Measurements of the magnetic properties of the metal grains to constrain the magnetic field around the young Sun.

References

- [1] A. Meibom *et al.* (1999) *LPSC XXX*, 1411. [2] M.K. Weisberg *et al.* (1999) *LPSC XXX*, #1416. [3] M.I. Petaev *et al.* (1999) *LPSC XXX*, 1613.